OGLALA SIOUX OF PINE RIDGE RESERVATION HOUSING AUTHORITY TRIP REPORT

Assessment of Mold and Moisture Conditions

Final Report

Date:
July 12-16, 2004

Prepared for:
U.S. Department of Housing & Urban Development
Office of Native American Programs

Prepared by:
UIUC/Building Research Council
One East St. Mary's Road
Champaign, IL 61820

Under sub-contract to:
Magna Systems, Inc.
340 E. Second Street, Suite 409
Los Angeles, CA 90012-4249
UI02 HUD SBC-B-2366

TABLE OF CONTENTS

PART I

OGLALA SIOUX OF PINE RIDGE RESERVATION HOUSING AUTHORITY TRIP REPORT

INTRODUCTION

Jeff Gordon, Bill Rose, and Yelias Bender of the Building Research Council (BRC) at the University of Illinois Urbana-Champaign conducted a site visit at the Pine Ridge Reservation on July 12-16, 2004. The purpose of the site visit was to provide technical assistance to the Oglala Sioux of Pine Ridge Reservation Housing Authority (OSPRRHA) in assessing mold and moisture conditions in housing units. The following report summarizes the activities undertaken and issues addressed while on site. A detailed analysis of the findings and recommendations is found in the attached reports, entitled: *Oglala Sioux of Pine Ridge Reservation Housing Authority Technical Housing Assessment Report: Examining Mold and Moisture Conditions of Homes on the Pine Ridge Reservation.*

BACKGROUND INFORMATION

Day 1: Tuesday, July 13, 2004

On Tuesday morning, the research team met with the site liaison, Rick Palmier. The primary concerns of residents on the reservation were briefly discussed and an outline the team's role while on the reservation was created. Present at the meeting were Jeff Gordon, Bill Rose, Yelias Bender, and Rick Palmier.

Following the meeting, the group visited four homes. In each case, Bill Rose and Jeff Gordon performed visual inspections of the homes' physical conditions and took digital photographs to record conditions. Meanwhile, Yelias Bender conducted interviews with available occupants.

Both Gordon and Rose noted mold and moisture problems, the extent of which, and their possible causes, are discussed below in the *Findings* section.

Assessments were conducted on homes within three residential areas of the Reservation: Pine Ridge, Wounded Knee, and Mandersen.

Day 2: Wednesday, July 14, 2004

After discussing the previous day's findings, the team inspected four additional units. Findings similar to the previous day were recorded, and the attached *Oglala Sioux of Pine Ridge Reservation Housing Authority Technical Housing Assessment Report* provides a detailed analysis of the results and recommendations for the homes investigated.

Day 3: Thursday, July 15, 2004

On Thursday morning Jeff Gordon and Bill Rose conducted a training session for the OSPRRHA maintenance staff, as well as Kathy Janis of the Oglala Sioux Tribal Council (OSTC) and Jeff McDonald of the Oglala Sioux Tribal Council Research and Development team. Items discussed included: (1) a background on what mold is, (2) preliminary findings relating to mold and moisture problems, (3) potential causes for those problems, and (4) mold remediation techniques. The sign-in sheet for this training session is appended to this report as Attachment 1.

FINDINGS

An overview of findings for the Pine Ridge Reservation housing site visit follows. The *Oglala Sioux of Pine Ridge Reservation Housing Authority Technical Housing Assessment Report* contains a detailed discussion and recommendations based on these findings.

1. Exterior site drainage and rainwater management was a problem in most of the homes. The poor site drainage and rainwater management led to high moisture loads on the building foundations. Gutters and downspouts were in poor condition. Low spots caused by erosion of the soil next to the buildings were a problem at nearly every site. The effect of these depressions was compounded by the walkways that surround the houses and prevented the rainwater from draining effectively.

2. Many inspected homes were overcrowded, increasing the moisture generated from human sources, contributing to elevated interior moisture loads, and ultimately (if other conditions are in place) leading to mold contamination from condensation problems. There was condensation and related mold contamination in five inspected homes with overcrowded conditions.

3. The bathrooms in the inspected units showed mold growth. Three homes had showers in the basement, two of which were enclosed only by surfaces of painted concrete masonry units. The interior surfaces of these showers showed considerable mold growth, caused by wetting of the surfaces which are porous and painted, and by slow drying in the absence of a vent fan.

4. Six homes were on basements. The poor rainwater management around the building led to the appearance of mold in all of the basement units. Two of the homes had crawl spaces. The crawl spaces were practically impossible to inspect because of low clearance, being poorly insulated, showing evidence of poor construction work, and showing signs of contribution to moisture problems in the units.

5. As a consequence of the moisture sources cited above (poor rainwater management, overcrowding, showers with porous surfaces and crawl spaces) many interior surfaces showed mold growth. This was most common on basement walls and on the surfaces

of above-grade walls in closets, corners, near heavy furniture, and at the exterior wall/ceiling junction.

PROGRAMMATIC RECOMMENDATIONS

The findings are closely tied to one another, thus to properly address them all effectively, they must be dealt with in concert. Mitigating each one in isolation will not help to improve the overall condition of the units with respect to mold growth and moisture loading. The following recommendations are based on this premise:

1. Improve the rainwater control for the building site. This may involve occasional regrading and replacement of eroded topsoil, together with a plan for using a hardy plant cover for the soil. Also include the placement of culverts on the surface or drain tiles beneath the surface to prevent the erosion taking place. The erosion leads to local soil depressions near the building that capture rainwater and lead to water leaks and mold growth at the foundation.

2. Abandon the use of cast-in-place sidewalks around the homes, which act as dams preventing the effective discharge of rainwater away from the building. Consider the use of isolated pavers instead.

3. Repair or replace damaged gutters. Ensure continued maintenance of gutters.

4. Overcrowding plays a fundamental role in each of the remaining four problems above, by amplifying the problems. During the training session held Thursday, July 15th, members of the OSTC and HA emphasized the need to mitigate overcrowding. Increasing the housing supply through construction is ideal and has started to take place at Wounded Knee.

5. Address bathroom mold problems by scrubbing affected surfaces with detergents. If the surfaces are painted, then assure the surfaces are dry, then repaint using zinc oxide paint. Install effective vent fans rated for 80 CFM of air movement and for low sone rating. The fan controls should permit operation for a short time (approx. 10 minutes) after the bathroom light has been turned off.

6. Solve mold problems in basement showers by cleaning (as described above) and installing proper shower surrounds (fiberglass resin or PVC) on the block walls. Clean and repaint the floor and ceiling surfaces using an industrial coating, such as epoxy paint. Place a lamp in the shower—infrared heat reduces moisture on the surface and UV light inhibits mold growth. Install an effective vent fan.

7. Basement and crawl space problems are alleviated primarily by exterior rainwater management. Clean and repaint basement surfaces affected by mold as necessary. Clean to improve accessibility in crawl spaces. If exterior rainwater management improvements do not result in dry crawl spaces, then install a drainage system in crawl spaces.

Attachment 1

SIGN IN SHEET

DATE: July 15, 2004

	NAME	DEPT.
1.	Rob Roberts	Maint.
2.	[illegible]	WRD
3.	William B Reese	U of T
4.	Yelias Bender	Univ of Ih
5.	[illegible]	U of I
6.	[illegible]	[illegible]
7.	[illegible]	ED Maintenance
8.	Judy Hamblin	T.S.R.
9.	Peter Eagle Bull	TSR
10.	Carolyn Mantcher	T.S.R.
11.	Richard Hill	Maintenance
12.	Colen Two Bulls	maintenance
13.	Carrie Blackstock	maintenance
14.	[illegible]	
15.	[illegible]	OST Council
16.	[illegible]	OST Research & Development
17.		
18.		
19.		
20.		
21.		
22.		
23.		

PART II

OGLALA SIOUX OF PINE RIDGE HOUSING AUTHORITY

TECHNICAL HOUSING ASSESSMENT REPORT

EXAMINING MOLD AND MOISTURE CONDITIONS IN HOMES OF THE PINE RIDGE RESERVATION

EXECUTIVE SUMMARY

The site assessment team inspected eight homes in the Pine Ridge Reservation of the Oglala Sioux for moisture and mold conditions. The principal findings derived from the inspections included:

1. Exterior site drainage and rainwater management was poor in the eight homes, leading to high moisture loads on the building foundations. Gutters and downspouts were in poor condition. Low spots caused by soil erosion next to the buildings were a problem at nearly every site. The effect of these depressions was made worse by the walkways surrounding the homes and did not permit the rainwater to drain away effectively.

2. Many homes were subject to overcrowding, which increases the moisture generated from human sources, can contribute to elevated interior moisture loads, and ultimately (if other conditions are in place) lead to mold contamination from condensation problems. There was condensation and related mold contamination in five overcrowded homes.

3. The bathrooms showed mold growth. Three homes had showers in the basement, two of which were enclosed only by surfaces of painted concrete masonry units. The interior surfaces of these showers showed considerable mold growth, caused by wetting of the surfaces which are porous and painted, and by slow drying in the absence of a vent fan.

4. Six homes were on basements. The poor rainwater management around the building led to the appearance of mold in all of the basement units. Two homes had crawl spaces, practically impossible to inspect because of low clearance. They were poorly insulated, showed evidence of poor construction work, and showed signs of contributing to moisture problems in the units.

5. As a result of the moisture sources cited above (poor rainwater management, overcrowding, showers with porous surfaces and crawl spaces) many interior surfaces showed mold growth. This was most common on basement walls and on the surfaces of above-grade walls in closets, corners, near heavy furniture, and at the exterior wall/ceiling junctions.

This report provides technical recommendations and discussions focusing on these items. Appendix A includes a summary of findings from the inspections. Appendix B provides a detailed assessment of each home.

INTRODUCTION

The assessment team responded to a request from the Southern Plains Office of Native American Programs to assess site and building structural conditions contributing to mold and moisture problems at the Pine Ridge Reservation. Jeffrey Gordon and William Rose, and Yelias Bender, Building Research Council staff conducted the investigations on July 14–16, 2004. Rick Palmier, Oglala Sioux Tribal Council, and a member of the HA maintenance staff escorted the inspection team.

The Pine Ridge Reservation covers five counties in southwestern South Dakota, as well as Off Reservation Trust Land in northwestern Nebraska. The region's climate is highly variable, ranging from hot, dry summers to generally harsh winters. The region has many lakes, streams, and rivers among rolling hills. Almost 15,498 Native Americans reside on this Reservation. The Housing Authority manages 1152 Low Rent homes 462 Mutual Help homes, and currently has six homes in development. No Turnkey III homes exist on Pine Ridge. Rick Palmier coordinated the site visits.

SECTION 1 - METHODOLOGY

Visual Inspection

Housing inspections consisted primarily of visual assessment of mold and moisture conditions. The assessment forms were organized for a room-by-room inspection. All rooms were examined for water damage and evidence of mold. Assessment of kitchens, bathrooms, basements, crawl spaces, utility rooms and attics included additional inspection relating to plumbing, localized ventilation, water entry and other moisture source issues.

The exterior of the homes were inspected for rainwater/snow melt management, including site grading, roof condition and gutter system.

Whenever possible, residents were interviewed to gather history on moisture problems, plumbing leaks, winter condensation, health issues, number of occupants, and other related information.

Digital photographs were taken at each home to visually record notable conditions.

The results of the mold and moisture assessments were compiled on a spreadsheet, with broad categories of common moisture problems noted. This data is presented in Appendix A in this report. The findings from each individual home inspection are presented in Appendix B.

SECTION 2 – PINE RIDGE RESERVATION HOUSING TYPES

The Oglala Sioux of Pine Ridge Housing Authority is responsible for over 1,600 homes in various programs. The assessment team examined eight homes for mold and

moisture. These eight homes do not represent a typical cross-section of the units under their management, since the selection was not based on a random sample.

Two homes were wood-framed ranch homes on crawl spaces. The other six were bi-level homes, with the front entry leading to a landing that allowed one to climb up a half-floor to the top story or descend a half-floor to a lower level. The lower level sometimes had two bedrooms in the front of the home and a large room for mechanical services at the back of the home.

SECTION 3 – FINDINGS

There was mold growth in all the inspected homes. In some cases, mold contamination was slight and limited to bathrooms. In other cases, mold contamination was extensive and acute throughout the home. Mold on building surfaces is associated with moisture problems. The following are general findings based on the inspection of the homes at the Pine Ridge Reservation:

Figure 1: Substantial damage to gutter from overgrown tree and brush.

3.1 Exterior Site Drainage and Rainwater Management

Site rainwater management was poor at all eight homes. Good rainwater management begins with good gutter and downspout systems. Many of the gutters were in poor condition from physical damage or from overgrowth (Figure 1).

Figure 2: Erosion of soil around the home, due to surface flow of rainwater.

Many downspouts discharged their water right at the foundation of the building, rather than onto splash blocks designed to carry water away from the foundation. Gutters were in poor condition in all the inspected homes.

Most of the homes had walkways partially surrounding them (Figure 2). One home under construction, visited but not inspected, had a new walkway around the building. The soil that was once at the level of the sidewalk had eroded and now the sidewalk appeared suspended above the soil grade. There was very little lawn or other plant growth on the soil surface around these homes. This was because of; 1) local soil that did not easily support plant growth, 2) human traffic around the homes and 3) erosion by rainwater. If the soil between the walkway and the home erodes, it forms a basin that hinders water drainage away from the foundation.

3.2 Overcrowding

Excessive occupant density in the homes averaged 9 persons per housing unit or 2.6 per bedroom. Of course, the occupant numbers varied over time. The overflow of occupants in the Pine Ridge housing was in basement areas not designed as bedrooms. The partitions separating bedroom areas from other areas were often made of hanging blankets or other fabrics between the areas.

Figure 3 shows a bedroom located in a basement room. The water problem and consequent mold growth on the wall of this room is evident in the photograph.

Figure 3. A basement corner used as a bedroom, a consequence of overcrowding.

3.3 Bathrooms and Basement showers

The bathrooms in all the homes had some mold growth at the tub surround, between the tub and toilet, and on the bathroom ceiling. Major mold growth was found in basement shower units. Some 3 and 4-bedroom homes were designed and built with small (measuring only two feet in width) showers in the basement. In two of these homes the inside surfaces were painted concrete masonry. There was no mechanical ventilation. Under normal use, the painted surface adsorbs considerable quantities of water and the drying process is very slow. The mold growth on these surfaces was extensive on the floors, ceilings, and walls (Figure 4).

Figure 4. Basement shower with surfaces of painted concrete block.

3.4 Basements and Crawl Spaces

When rainwater is poorly managed, the soil that is in contact with the building foundation can become saturated, making the foundation materials themselves wet or leaking into the interior. All six basements showed mold growth on the basement wall surface.

Two homes were on crawl spaces. At the time of inspection, the crawl spaces were dry and dusty. There was evidence that water had entered the crawl spaces at times, namely watermarks on the ground cover and dirt streaks on the vertical walls. The water that entered the crawl space appeared to run from outside due to poor rainwater management, rather than rising groundwater. No direct evidence of the crawl space leading to mold

growth in the homes was found, but, since water had entered into crawl spaces and wet crawl spaces tend to lead to mold problems, they are included here as an important factor.

Crawl spaces are rarely visited, and construction defects are common. In one crawl space, a plumbing drain line was unsupported for a length of approximately 30 feet, causing the pipe to sag in the middle and risk rupture.

3.5 Mold growth on chilled surfaces

All the homes showed some mold growth as a combined result of indoor humidity in contact with cold surfaces. The most common sites of mold growth were basement walls, bathroom walls, and ceiling surfaces. Several homes showed mold growth at a poorly insulated ceiling-wall juncture. In one case, mold on the surface was associated with the use of a humidifier during cold weather. In another case, mold appeared behind bedding at a wall with poor drainage and signs of occasional wetness in the crawl space below.

SECTION 4 - TECHNICAL DISCUSSIONS AND RECOMMENDATIONS

The following discussions and recommendations are based on the seven general findings identified during the site visit to the Pine Ridge Reservation of the Oglala Sioux.

4.1 Site Drainage and Rainwater Management

4.1.1 Site Drainage

Design and build the roof so that the water that lands on the roof, moves out to the edge of the roof, percolates downward through the soil—more in sandy soils and less in clayey soils, or moves along the soil surface following the slope, out to the downhill edge of the site. The best way to prevent mold and moisture problems in homes is to make sure that rainwater moves off the roof, across the site and off the property. The homes with problems are those that allow water to accumulate in the soil that is in contact with the foundation. In a well-managed property, the soil that is in contact with the foundation should be the driest soil on the site following a rainstorm. Homes with dry foundations (basements, crawl spaces and slabs) are usually dry homes. Keeping the foundation dry is the key to a good indoor environment in most homes. To keep the foundation dry, keep the soil dry that is next to the foundation.

Keeping the soil that touches the foundation dry involves two general rules and several specific guidelines.

The first general rule is concentration - damage is worse where greater quantities of water are concentrated. A valley on a roof acts like a funnel, with the greatest concentration of water at the base of the valley. Gutters also act like funnels that collect water from the edge of the roof and concentrate it in the downspout. On the land, valleys and swales act like collectors or funnels that concentrate the water on the site. If the water management

design makes use of funnels (such as valleys, gutters or swales) then they require maintenance to make sure they work as intended. Damage is worst where a valley, gutter or swale is blocked.

The second general rule is the ground roof rule - treat the soil surface as if it were a low-slope roof surface. Pitch the surface away from the home - the steeper the pitch, the better the drainage. Imagine all the water moving to the low edge of the site, and imagine how best to get it there. Avoid areas near the building that can act as water collectors.

Specific site drainage guidelines include:

- The home should be built on a crown, not in a hole. If there is sufficient exposed foundation, site grading at the home can be improved. If the home hugs the ground, improvements at the foundation are more difficult. There should be a minimum of eight inches of exposed foundation between the ground and the beginning of the siding.

- Identify localized dips and holes immediately adjacent to the foundation, fill with dirt, and tamp the fill material to prevent future settling. Provide sufficient fill material such that drainage occurs away from the foundation.

- If the home has no gutters, then the base of the soil around the home has to serve as a gutter. It should have a surface that helps prevent splash back onto the siding of the home and should be designed with pitch so that it effectively moves water away from the home.

- Good tamping or compaction of the backfill is very helpful because it helps keep water on the surface where it can be managed by slope. Soil at the outside corners of the foundation, where the downspouts are usually found, can always be tamped because the corner will not collapse inward.

- Bushes and other plantings may be very helpful, especially if their root balls soak up a lot of water. Also they can be planted near downspouts so the downspout extenders are less likely to be kicked off or removed during lawn mowing.

4.1.2 Gutters and Downspouts

Collect rainwater and snow melt from the roof and distribute it away from the foundation with a gutter system. Clean and occasionally repair gutters. If trees and shrubs encroach on the roof edge, as was seen at Pine Ridge, trim them.

Downspouts should discharge water a distance away from the building foundation. If they discharge water right at the building foundation, basement and crawl space walls are likely to become wet and leak water into the foundation area. Usually downspout extenders, splash blocks or a combination of the two is used to get water away from the

foundation. Slope the soil at the base of the downspout away from the home at a minimum of 5% slope with six inches of fall in the first 10'.

The two principal rainwater management problems encountered at Pine Ridge are soil erosion and surrounding walkways.

4.1.3 Soil Erosion

The soil surface near most inspected homes was quite bare of grass or other ground cover due to 1) soil properties, 2) foot and vehicle traffic, and 3) erosion of topsoil. The properties of the soil in place cannot change, but new soil more conducive to growth of ground cover can be made available. Foot and vehicle traffic is inescapable around a residence, but the volume of traffic may be associated with the population density (see below). If the soil is left bare and the downspouts discharge water onto the soil surface, then erosion is an inevitable consequence. It should be noted that soil erosion is associated with general water flow on the site during rainstorms, not just with water that is discharged from downspouts.

There are two ways to address this problem:

1. Permit erosion to continue. Solve basement water problems as they occur. Occasionally provide new topsoil and re-sod.

2. Design the building site for controlled water flow without erosion.

We were told that Option 1 has been exercised, and that there has been occasional regrading of the sites. A local agronomist or plant expert could determine what plant material is most hardy under the conditions of use.

To exercise option 2, design and implement an appropriate water channel, such as a surface channel of asphalt, concrete or masonry, or a below-grade system of collector drains and conduit drains. It would have to be very well designed, because if concentrated water is permitted to flow along pathways that are not in the designed system of flows, then that system could be undermined and left high.

4.1.3 Surrounding walkways

Most inspected homes had concrete walkways that surrounded the home, typically on the sides and front of the home. They were outboard of the home by 3-6 feet. Soil erosion removed soil from between the home and the sidewalk and left the sidewalk suspended. This poses as a water and safety hazard, retaining water close to the home foundation. Design walkways to not act as dams, keeping water close to the home. Provide discontinuous pavers for walkways rather than the continuous concrete walkways that are in place now. Even if soil erodes from around the pavers, they would be easier to reset and to grade than the continuous concrete walkways are. Alternative means that permits water to pass through the walkway, such as a pipe or a gravel water channel, would be helpful.

4.2 Overcrowding

Human occupation naturally produces moisture in buildings. Generally, human moisture sources alone will not produce enough moisture to cause winter condensation and mold problems in the winter. However, there are two circumstances when the human moisture sources may result in problems:

Figure 5. Mold growth due to cold surfaces (corner condition) and blocked surfaces. The bed was moved away from the wall in order to take the photo.

1. Overcrowding. When the number of residents living in a home is clearly excessive for the size of the home, the moisture burden increases. Each person is participating in the moisture-producing activities (breathing, cooking, washing, etc.). If the number of people for the capacity of a home doubles, the moisture load from human sources also doubles.

2. Weather-tight construction. In the absence of a mechanical ventilation system, natural infiltration (air leakage) is the source of fresh air in homes during the winter. It is this fresh, dry, winter air that dilutes the moisture in the interior air and helps keep relative humidity under control. The amount of infiltration (the air change rate) that occurs in a home varies depending on the home. Some homes are naturally leaky, while others are more airtight. A particularly tight home may exhibit high relative humidity in the winter, which could lead to moisture and mold problems.

When these two conditions are present in the same home, that is, when a home is overcrowded and exhibits a low air change rate, an excessive moisture load can occur and maximize the potential for localized condensation and mold growth. The locations of mold growth are likely to be:

1. Cold surfaces. Areas of the building envelope that are not well insulated will appear (during cold weather) as surfaces with colder temperatures. The wall-ceiling juncture is an example of a colder surface due commonly to discontinuity in the insulation. Another example is a building corner.

2. Blocked surfaces. When furniture is against a wall, heat cannot flow easily to the surface, and it tends to get cold during cold weather (Figure 5). Heat is not supplied to closets and stored materials act as insulators. These two effects combine to create colder surfaces in closets that are common sites for mold growth.

3. Bathrooms. Bathrooms have a higher humidity load. Install and use quiet, effective vent fans in order to reduce the bathroom humidity. Fans controlled to run after the bathroom is no longer in use provide reduced humidity.

Overcrowding can lead to clutter, making cleaning and vacuuming more difficult resulting in dirt and dust build up. In homes where dirt accumulates, it becomes difficult to determine the extent of mold growth. Given the visual similarities between dirt and mold, a mold assessment can never be considered definitive in a dirty dwelling. A cluttered unit makes access to building surfaces difficult.

Any recommendations related to overcrowding must be developed in coordination with housing policy and enforcement. This report contains only a general recommendation to avoid overcrowding.

4.3 Bathrooms and Basement Showers

4.3.1 Bathrooms

Several of the units had mold growth in bathrooms. Remove mold growth by scrubbing with detergent and dry the surfaces afterward. Repaint painted surfaces with Kilz or other paint containing zinc oxide. Remove and replace water-damaged drywall.

Bathrooms are the sites of many mold and moisture problems, because they are the wettest rooms in homes. Keeping bathrooms dry depends on care in several areas:

Bathroom plumbing should not leak in either the water supply system or the drain-waste-vent (DWV) system. Fix all plumbing leaks promptly. Some leaks may be hard to detect, such as a leak at the toilet flange or a leak at a shower drain.

Be careful when you use bathrooms. Close the shower curtains securely so that all the water goes into the tub and none escapes out. Toilet users should be careful. Select and install surfaces in the bathroom to keep water away from drywall and other materials that may permit mold to grow. Clean any spills up promptly. Clean any dirty and discolored spots. Correct any water problems that may have led to the spotting. Remove and replace damaged drywall. Keeping surfaces clean and dry is primarily the responsibility of the residents of a home

Bathrooms are natural moisture sources simply by the nature of their function. Showers result in 100% humidity in that room. By removing moisture at the source in these areas, exhaust ventilation serves as a source control strategy for reducing the moisture load in a home. Exhaust ventilation dilutes the moisture and places the room in a negative pressure, thus limiting the spread of moisture to the rest of the home until most of the moisture has been removed to the outside.

Vent bathroom exhaust fans to the outside rather than into the living space. Also, venting to the basement, crawl space and attic can lead to moisture problems occurring in these areas. For this reason, localized exhaust ventilation requires ductwork. If the vent discharges through the roof, make sure the vent has an effective check valve to prevent wind blowing back through the vent. The vent may discharge out at the soffit area, but the vent duct should penetrate through the soffit panels and terminate in a grille.

Bathroom exhaust fans should exhaust approximately 80 cubic feet per minute (CFM). The effectiveness of exhaust fans is based on the power of the exhaust fan, length and type of exhaust duct and cleanliness of the fan grille. When there is excessive resistance in the ductwork, the exhaust fan motor may not be powerful enough to vent sufficient airflow through the duct. The longer the duct length, the greater the static pressure in the duct and the less air flow through the duct. Turns and bends in the ductwork also increase the static pressure and reduce flow. Similarly, a smooth duct provides less resistance and improved flow over ribbed ductwork. For all types of exhaust ventilation, using round, smooth sheet metal ductwork is recommended. Generally, the larger the duct, with the fewest bends or elbows, and the shortest duct run, is preferred. A dirty intake grille will also greatly increase resistance and reduce airflow.

Noisy exhaust fans are not likely to be used, so exhaust fans with a low "sone" rating should be selected. To ensure they get used, consider:

- Exhaust fan hard-wired to the bathroom light, and/or
- Exhaust fan on a timer, to extend moisture dilution time following a shower.

A good combination control features both of these approaches, where the fan is hard-wired to the light, but also runs for a programmed period following bathroom use. (Available from Energy Federation Incorporated, www.efi.org, Fan/Light Time Delay Switch). Residents should be encouraged to always use the bathroom exhaust vent.

4.3.2 Bathroom showers

Five homes had showers in the basement made of painted concrete blocks (CMU). Mold growth was extensive in all of the shower compartments. Mold growth on these surfaces was due to 1) wetting of the surfaces, 2) porosity of the surfaces that retains a significant quantity of water, 3) small size, restricting air flow, and 4) lack of ventilation. The surface was covered with paint and soap, both of which are sufficiently organic to provide nutrients to mold.

Clean and scrub the shower compartments to remove the bulk of the mold material. Then line the showers with an appropriate shower compartment liner material, usually of fiberglass-resin or PVC. Some industrial paints such as epoxy may be suitable for providing scrubbable surfaces. These may be most helpful on the ceiling and floor of the shower compartment, which are also affected by mold growth. Install a fan and controlled it to run long enough after the shower to provide significant drying to the surfaces. A strong lamp with heat (IR) may help dry the surfaces and short-wave (UV)

radiation may help kill or block fungal growth. A flood lamp provides IR and UV, as well as visual light.

4.4 Basements and Crawl Spaces

4.4.1 Basements

Because they are below-grade spaces, basements are prone to water and mold problems. They require good rainwater management outside the building. If water is allowed to collect around the building without being drained away, that water can move by gravity or capillary action to the inside of the foundation. All six basements had mold problems.

Correct the problem by scrubbing with detergent. The surface can be repainted, preferably with a paint containing zinc oxide such as Kilz.

4.4.2 Crawl Spaces

Moisture entry and evaporation from foundation sources are major contributors to the moisture load in a home. Because they are rarely visited or inspected and problems go unaddressed, crawl spaces are particularly notorious for leading to foundation moisture problems. When moisture entry is acute, framing and subflooring can deteriorate and support mold. The following points relate to crawl spaces in general, regardless of thermal boundary.

1. Crawl spaces should have easy access and good lighting so as to enable regular inspections. There should be sufficient headroom to allow for reasonable ease of movement and ability to perform repairs and improvements. Most building codes require at least 18" of clearance. In order to facilitate inspection, the crawl space average clearance should be at least double that.

2. Water in crawl spaces typically comes from poor outdoor rainwater management, plumbing leaks, air conditioner condensate or water softener discharge. Poor rainwater management is by far the leading source of water in crawl spaces.

3. The soil surface should be either level or sloped to drain to a sump pump. There should be no debris. Cover crawl spaces with ground material: a slab of concrete, a polyethylene sheet, or other vapor-proof material. Seal joints and seams in the polyethylene.

4. Insulate crawl spaces. In units such as those at Pine Ridge with ductwork and plumbing in the crawl space, insulate the walls rather than the floor system.

The crawl spaces were dry, but showed signs of previous water entry. They had polyethylene ground covers, but very low clearance and spider webs throughout made the prospect of moving through the crawl space disagreeable. There were signs of occasional flooding in the crawl spaces.

Figure 6. The opening between the crawl space and outdoors has a greater potential for water entry than the potential for drying. The term "vent" is inappropriate in this case.

Since the 1940s, vents have been recommended as a method of moisture control in crawl spaces. Lately, the effectiveness of crawl space vents has been questioned. The ability of vents to dry the wet crawl spaces is limited by the amount of air that moves through the vents, and by the difference in humidity content between the incoming and outgoing air. That amount is generally quite small. On the other hand, vent openings are often installed at or near grade, and in this location, water can enter through the openings (Figure 6), rendering them not ineffective. More water can enter through the vent than can be dried by air moving through the vent.

The recommendations for crawl spaces follow:

1. Improve the site water drainage to prevent water entry into the crawl space.
2. Clean cobwebs from the crawl space.
3. Inspect the crawl spaces for mechanical or plumbing problems and make any necessary corrections.
4. If exterior rainwater management proves to be insufficient in providing a dry crawl space, then provide for interior rainwater collection and discharge. This may involve:

    a. Providing a perimeter collector (perforated) drain just beneath the soil surface,
    b. Regrading the soil surface to pitch at a 5% slope to a sump pump
    c. Providing conduit (unperforated) drains from the collector drains to the sump pump,
    d. Providing an effective means of discharging the sump pump water away from the home.

4.5 Mold and moisture on chilled surfaces

Condensation occurs when moisture-laden air comes in contact with a building surface chilled below the air dew point, increasing the moisture content of the materials at the location and mold grows on the surfaces. This problem indicates a combination of two factors:

1. A home with a high wintertime moisture load (relative humidity).

2. Areas of the building that are below the desired interior temperature.

In cases where this problem occurs two approaches address the problem:

1. Identify the moisture sources that contribute to the elevated humidity in the home and reduce or eliminate these moisture sources, and

2. Identify the cause of the chilled surface and add insulation or airflow improvements to reduce or eliminate the chilling of the surface.

4.5.1 Load reduction

Identifying and reducing moisture sources to lower relative humidity in the winter is always the first step. Moisture sources can include:

- Foundation moisture sources – wet basements and crawl spaces.
- Bathroom moisture sources due to lack of localized ventilation.
- Human moisture sources which result from overcrowding.

All three sources were identified in the Pine Ridge homes experiencing condensation problems. The problem is related to other issues discussed individually in the report, including site drainage and rainwater management (Section 4.1.), overcrowding (Section 4.2.), bathrooms (Section 4.3.), and basement and crawl space design (Section 4.4.). Minimizing these moisture sources is discussed in the respective sections.

4.5.2 Raising surface temperatures

Maintaining surface temperatures above the dew point temperature is the second approach. Consider moisture source control first, because the lower the relative humidity, the lower the temperature that is tolerable. The problem can occur, however, at a reasonable interior humidity if there is a specific construction flaw that allows a surface to get chilled in the winter.

A common condition leading to winter condensation and mold problems occurs in closets on an exterior wall. The design and use of closets conspire to make this condition common, specifically:

- Lack of heat supplied to closets and closed closet doors.
- Lack of airflow in closets, which would distribute heat to the closet exterior surface.
- Closet clutter that prevents airflow and heat to reach the closet exterior wall.
- Clothes hanging against the wall, which act as insulation and lower the temperature of the wall.

Closet doors may be louvered. Signs or spacers may be used to help keep clothes from being in contact with the outside wall.

When furniture is placed against a wall during winter, the furniture may act as an insulator, lowering the temperature of the wall surface. Do not place beds directly in contact with cold outdoor walls.

4.5.3 Wall-ceiling juncture

Another location that commonly experiences chilling and subsequent condensation and mold contamination is at the wall/ceiling juncture on exterior walls. This is a very common problem in northern climates in older ranch-style homes with low-pitched roofs. This problem was identified in Pine Ridge housing.

Three reasons why the exterior wall/ceiling juncture gets cold (Figure 7):

1. Cold wind may enter through soffit vents and pass through the porous insulation material, degrading its thermal performance.

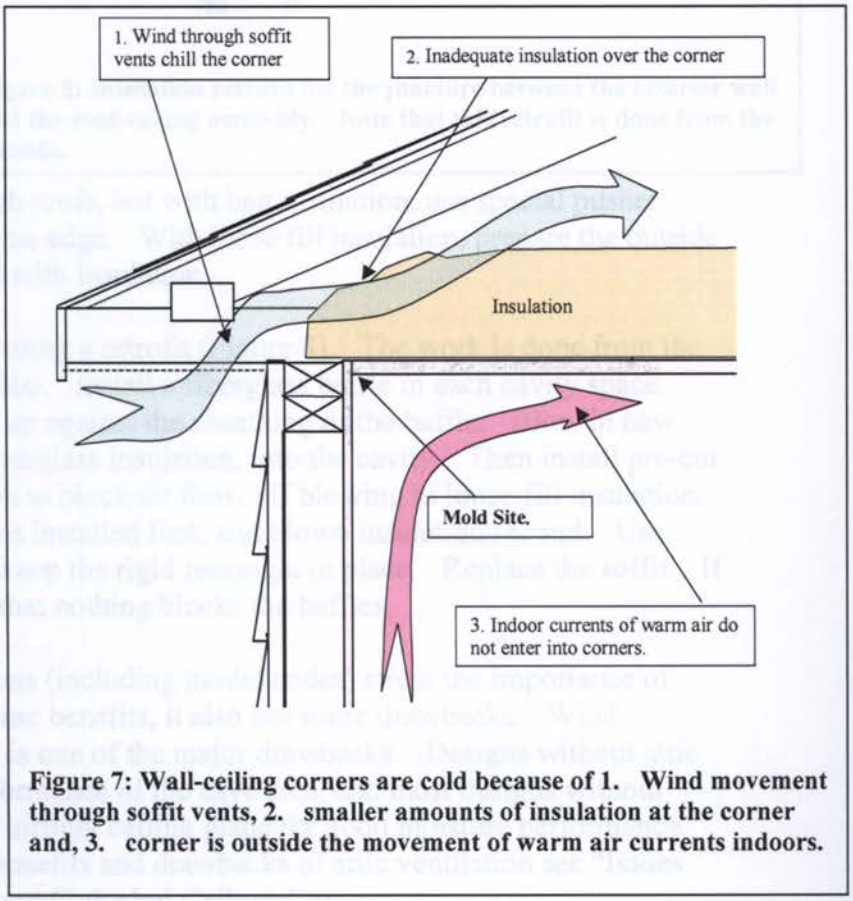

Figure 7: Wall-ceiling corners are cold because of 1. Wind movement through soffit vents, 2. smaller amounts of insulation at the corner and, 3. corner is outside the movement of warm air currents indoors.

2. The insulation may have been poorly installed resulting in reduced amounts of insulation in the corner.
3. The geometry of the corner usually means that slow-moving currents of warm air may not be able to reach into the corners.

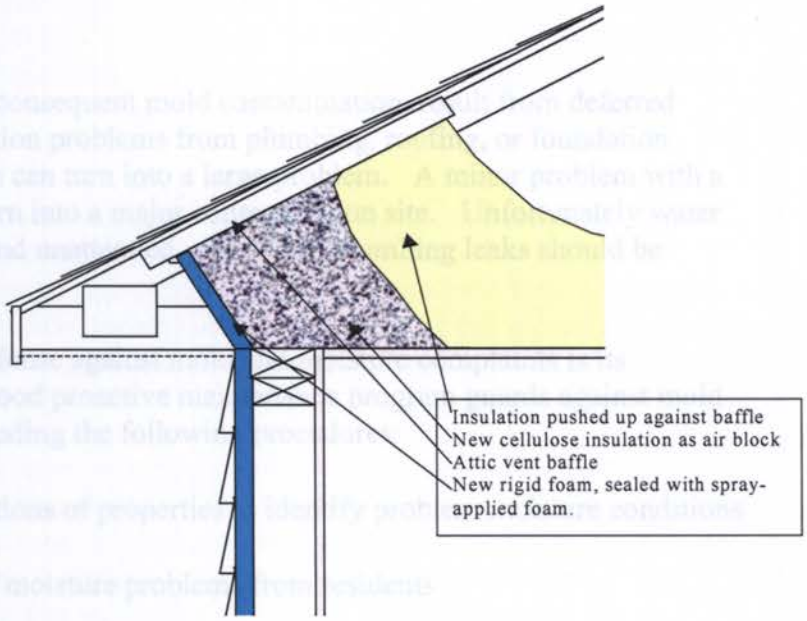

Figure 8: Insulation retrofit for the juncture between the exterior wall and the roof-ceiling assembly. Note that this retrofit is done from the outside.

Dark spots occur where the interior surfaces are the coldest, the hardest place to insulate effectively. In new construction, use a raised-heel truss and ensure the installer pays special attention to the wall-roof joint. It is difficult to carefully insulate the exterior edge of the attic, especially in homes with low-pitch roofs, but with batt insulation, use special pusher sticks to get the insulation out to the edge. With loose fill insulation, prepare the outside edge correctly so that it is packed with insulation.

In existing construction consider using a retrofit (Figure 8). The work is done from the outside. Remove the soffit material. Install a fiberglass baffle in each cavity space. Push the existing insulation back up against the sheathing or the baffle. Blow in new cellulose insulation, or pack in fiberglass insulation, into the cavity. Then install pre-cut rectangles of rigid foam insulation to block air flow. If blowing in loose-fill insulation, the rigid foam insulation should be installed first, and blown insulation second. Use spray-applied foam insulation to keep the rigid rectangle in place. Replace the soffit. If the attic is ventilated, make sure that nothing blocks the baffles.

Many individuals and organizations (including model codes) stress the importance of attic ventilation. While it has some benefits, it also has some drawbacks. Wind washing of insulation at the edge is one of the major drawbacks. Designs without attic ventilation may improve the performance of the eave area, and most designs without ventilation rely upon the verified airtight ceiling plane for good moisture performance. For more information about the benefits and drawbacks of attic ventilation see "Issues Related to the Venting of Attics and Cathedral Ceilings" at http://www.fpl.fs.fed.us/documnts/pdf1999/tenwo99a.pdf.

The retrofit presented is designed to keep the wall/ceiling juncture warm, and eliminate the condensation site. Lowering the moisture load in the home and reducing the relative humidity, also helps prevent wintertime mold and moisture problems.

4.6 Maintenance Issues

Many moisture problems, and consequent mold contamination, result from deferred maintenance. If water infiltration problems from plumbing, roofing, or foundation sources linger, a small problem can turn into a large problem. A minor problem with a small potential for mold can turn into a major contamination site. Unfortunately water leakages often go unreported and unattended. Roof and plumbing leaks should be attended to promptly.

A Housing Authority's best defense against mold and moisture complaints is its maintenance department. A good proactive maintenance program guards against mold and moisture problems by including the following procedures:

- Perform regular inspections of properties to identify problem moisture conditions
- Encourage reporting of moisture problems from residents
- Respond promptly to identified and reported moisture problems to prevent excessive mold contamination

Clearly, a prompt response implies a partnership between tenants and the housing authority. Residents must promptly report mold and moisture problems, and maintenance staff must promptly respond to the residents' reports. If either party defers in their responsibility, the list of deferred maintenance items will grow, and small moisture and mold problems will turn into major problems with possibly severe mold contamination. Maintenance staff should be trained in the following items to assist in solving and eliminating moisture and mold problems.

SECTION 5: SUMMARY OF RECOMMENDATIONS

1. Improve the rainwater control for the building site by checking and replacing eroded topsoil, together with a plan for using a hardy plant cover for the soil, by placing culverts on the surface, or drain tiles beneath the surface. The erosion of soil leads to local soil depressions near the building that capture rainwater and lead to water leaks and mold growth at the foundation.

2. Abandon the use of cast-in-place sidewalks around the homes. They act as dams preventing the effective discharge of rainwater away from the building. Consider the use of isolated pavers instead.

3. Repair or replace damaged gutters. Ensure continued maintenance of gutters.

4. Overcrowding plays a fundamental role in nearly each of the remaining four problems described. Nearly all of the major and minor problems mentioned in the *Oglala of Pine Ridge Reservation Housing Authority Technical Housing Assessment Report* are amplified by increased overcrowding. During the training session held Thursday, July 15th, members of the OST Council and Housing Authority greatly emphasized the need to mitigate overcrowding. Increasing the housing supply through construction is ideal and had started to take place at Wounded Knee.

5. Solve mold problems in bathrooms by scrubbing affected surfaces with detergents. If the surfaces are painted, assure the surfaces are dry and then repaint with paint containing zinc oxide. Install effective vent fans rated for 80 CFM of air movement and for quiet (low sone rating.) The fan controls should permit the fan to operate for a short time (approx. 10 minutes) after the bathroom light has been turned off.

6. Solve mold problems in basement showers by cleaning then installing proper shower surrounds (fiberglass resin or PVC) on the block walls. Clean and repaint the floor and ceiling surfaces using an industrial coating such as epoxy paint. A lamp in the shower would be helpful—infrared heat reduces moisture on the surface and UV light inhibits mold growth. Install an effective vent fan as described above.

7. Alleviate basement and crawl space problems by exterior rainwater management or an inside drainage system. Clean and repaint basement surfaces with mold. Improve accessibility in crawl spaces by cleaning.

1	2	3	4	5	6	7	8	10	11	12	13	14	15	16	17	18	19	20
Inspection Number	Address	HUD Program	Building Age	Occupancy	Bedrooms	Foundation Type	Model and Framing Type	Heat Type	Site Drainage Problems	Gutter System Problems	Leaks from Exterior	Wet Basement or Crawl Space	Plumbing Problems	Bathroom Problems	Exhaust Ventilation Problems	Condensation wall/ceiling problems	Attic Problems	Visible Mold (Column #)
1-1	95 E. Ridge	LR	38 years	10	4	Basement (concrete block)	Raised ranch; 2x4 wood frame	Natural Gas/Forced Air	Yes	Yes	Probable at chimney	Yes	No	Yes	Yes	No	Not Inspected	13, 14,16
1-2	197 E. Ridge	LR	34 years	7	3	Crawl space (concrete block)	Ranch; 2x4 wood frame	Natural Gas/Forced Air	Yes	Yes	No	Modest	No	Yes	Yes	Yes	Not Inspected	16, 18
1-3	185 E. Ridge	LR	34 years	5	3	Crawl space (concrete block)	Ranch; 2x4 wood frame	Natural Gas/Forced Air	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Not Inspected	14, 16, 18
1-4	27 N. Ridge	LR	43 years	9	4	Basement (concrete block)	Raised ranch; 2x4 wood frame	Natural Gas/Forced Air	Yes	Yes	No	Yes	No	Yes	Yes	No	Not Inspected	14, 16
2-1	475 Wounded Knee Housing	LR	28-30 years	9	4	Basement (concrete block)	Split level; 2x4 wood frame	Natural Gas/Forced Air	Yes, but minor	Yes	No	Modest	Yes	Yes	Yes	No	Not Inspected	14, 16
2-2	116 Wounded Knee Housing	LR	28-30 years	6	4	Basement (concrete block)	Raised ranch; 2x4 wood frame	Natural Gas/Forced Air	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Not Inspected	14, 16, 18
2-3	408 Mandersen	LR	28-30 years	12	4	Basement (concrete block)	Split level; 2x4 wood frame	Natural Gas/Forced Air	Yes	Yes	No .	Yes	No	Yes	Yes	Yes	Not Inspected	14, 16
2-4	435 Mandersen	LR	28-30 years	14	3	Basement (concrete block)	Raised ranch; 2x4 wood frame	Natural Gas/Forced Air	Yes	Yes	No	Yes	No	Not inspected	Not inspected	No	Not Inspected	14
									8	8	1	8	3	7	7	4		
									100%	100%	13%	100%	38%	88%	88%	50%		

LR = Low Rent MH = Mutual Help TK = Turnkey

Inspection Number: 1-1
Address: 95 E. Ridge
Model Type: Raised Ranch
Foundation: Basement
Construction: Block (CMU)
Heat Type: Natural Gas
Bedrooms: 4
Occupancy: 10
Age: 38 years

Figure 1 – 95 E. Ridge.

Mold and Moisture Conditions: Mold was visible within the basement and downstairs bathroom, major mold in the shower stall (Figure 2).

Figure 2 – Mold in the basement shower.

Site Drainage/Rainwater Management: The site sloped back to front. Erosion patterns showed that rainwater flowed along the house from the back to the front yard (Figure 3). Several gutter problems existed, including missing splash blocks, downspouts, and leaders (Figure 3). The front walk formed a dam allowing rainwater to pool against the foundation (Figure 4).

Figure 3 – Missing leader. Note erosion pattern.

Figure 4 - Sidewalk "dam".

Basement: The basement was wet and moldy (Figure 5), particularly at the corners where gutter leaders and splashblocks were missing at the front, low side of the house. The resident stated the basement only leaked once after a heavy rainstorm during the previous summer.

The worst mold contamination was in the basement bathroom shower stall (Figure 5). The shower surround was painted concrete blocks, a difficult surface to clean. There was no exhaust fan in this bathroom. Overcrowding and heavy usage of the shower without exhaust ventilation makes mold prevention difficult in these circumstances.

Figure 5 - Mold in the basement corner

Another location of mold contamination was identified on an interior wall in the basement, located adjacent to the furnace (Figure 6). The moisture source for this problem location is likely a roof flashing problem at the chimney vent (Figure 7).

Figure 6 - Mold on the wall near the furnace.

Main Level: Consequential moisture problems were not identified on the main level. The bathroom on the second floor had minor tile and grout damage, and the floor tiles around the toilet were deteriorated. These are anticipated maintenance issues that should be taken care of. There was no functioning exhaust fan in the main floor bathroom or kitchen.

Occupant Notes: With 10 people living in the home, the house was overcrowded. The occupants reported that one child had asthma, and all reported having respiratory problems (e.g., congestion) year-round.

Figure 7- Chimney vent and flashing

Recommendations:

1. Grade the yard and create swales to divert groundwater away from the foundation while it drains, following the natural slope, from the rear of the home toward the front of the house.
2. Repair damaged gutters and replace missing downspouts, leaders, and splash blocks.
3. Install a through-the-wall exhaust fan in the basement bathroom. Use controls to operate the fan for a specified time period after each shower.
4. After cleaning the mold off the shower walls, install a cleanable hard surfaced shower surround.
5. Inspect and repair the flashing around the chimney vent to prevent roof leaks.

Inspection Number: 1-2
Address: 197 E. Ridge
Model Type: Ranch
Foundation: Crawl space
Construction: Block (CMU)
Heat Type: Natural Gas
Bedrooms: 3
Occupancy: 7
Age: 34 years

Figure 1 - 197 E. Ridge.

Figure 2 – Trees causing gutter and roof damage.

Figure 3: Site drainage

Figure 4: Crawl space conditions

Figure 5: Bathroom mold.

Mold and Moisture Conditions: Mold was on the bathroom shower surfaces. There were minor condensation problems at the exterior wall/ceiling junction. The roof drainage system needed repaired.

Site Drainage/Rainwater Management: There were severe gutter problems: gutters were clogged, some downspouts were missing leaders, and trees growing adjacent to the house had crushed and disabled the gutters in some locations (Figure 2). The site was generally flat, with a depression on one elevation (opposite the driveway) that could trap rainwater next to the foundation (Figure 3).

Crawl Space: The crawl space was in good condition, with only modest signs of moisture (Figure 4). The walls were insulated and a plastic vapor barrier was in place.

Bathroom: Significant mold contamination was apparent on the wall and ceiling surfaces around the bathtub (Figure 5). Airflow capacity of the bathroom exhaust fan was insufficient.

Main Floor: The living room and kitchen had minor condensation-based moisture problems at the wall/ceiling junction.

Mechanical: The home was heated using natural gas and distributed via forced air.

Occupant Notes: Seven people occupied the home, creating an overcrowded situation. Occupants reported one infant may have asthma, since she had trouble breathing once she began living in the house.

Recommendations:

1. Make repairs to the gutter system. Remove trees that have grown too close to the foundation, causing roof and gutter damage. Replace missing leaders and maintain the gutters in a clean and functioning condition.

2. Clean the bathroom mold with detergent and water.

3. Replace the bathroom exhaust fan with a minimum 80 CFM fan, ducted to the exterior. Install a control on the fan that allows for delayed shut-off following bathroom use.

Inspection Number: 1-3
Address: 185 E. Ridge
Model Type: Ranch
Foundation: Crawl space
Construction: Block (CMU)
Heat Type: Natural Gas
Bedrooms: 3
Occupancy: 5
Age: 34 years

Figure 1 – 185 E. Ridge.

Mold and Moisture Conditions: Condensation-based mold was severe in one bedroom and present in two other bedrooms. Minor surface mold was visible on the bathroom tub/shower surround. Other moisture problems were apparent.

Figure 2: Sidewalk water dam

Figure 3: Destruction of gutter by tree

Figure 4: Crawl space vent.

Site Drainage and Rainwater Management: The site was generally flat, with some localized depressions next to the foundation. The sidewalk around the rear of the house trapped rainwater against the foundation (Figure 2). The gutter system was in need of repair and had missing downspouts and leaders. Trees growing next to the foundation were damaging the gutters and roof (Figure 3). Crawl space vents allowed water infiltration into the crawl space (Figure 4). The siding was deteriorated.

Crawl Space Conditions: There were signs of water intrusion into the crawl space (Figure 5). Water intrusion resulted from the concentration of rainwater against the foundation and from the vents. A drain pipe located in the crawl space was

Figure 5: Wet crawl space.

unsupported, raising the potential for serious flooding (Figure 6).

Figure 6: Unsupported drain pipe.

Bathroom/Kitchen: There was minor mold growth around the bathtub and on the bathroom ceiling. The bathroom exhaust bath fan operated at low efficiency. There was no water to the bathroom sink, and the drain was disconnected (Figure 7).

The kitchen had a gas range with no localized exhaust. A vented range hood, rather than the recirculating range hood, would be preferred.

Bedrooms: One bedroom, used as a storage room, had significant mold on the exterior walls (Figure 8). It is likely that placement of furniture against the walls contributed to this condition. The residents stated that this bedroom did not receive adequate heat in the winter, which would be a critical contributing factor in allowing the mold contamination. Four steps will be necessary to address the conditions in this room:

Figure 7: Disconnected sink drain

- Clean the contaminated surfaces and replacing drywall as necessary.

Figure 8: Severe mold contamination in bedroom.

Figure 9: Water damage below window.

- Lower the relative humidity in the residence.
- Ensure adequate heat to the bedroom.
- Avoid placement of furniture against the exterior walls.

A second bedroom had water damage under the window, though physical abuse may have contributed to the damage (Figure 9). Several rooms had staining and mold at the

wall/ceiling juncture on exterior walls (Figure 10). One bedroom closet had severe mold contamination at the base of the wall facing the exterior of the house (Figure 11).

Figure 10: Moisture at wall/ceiling juncture

Occupant Notes: Five people resided at this home. Occupants reported three had asthma and were also allergic to dust and pollen. Allergic reactions were described as especially bad for the occupants of bedrooms that contained mold.

Recommendations:

1. Make repairs to the gutter system. Remove trees too close to the foundation that caused damage. Replace missing leaders and maintain clean and functioning gutters.

2. Grade soil away from the foundation. Make alterations to the sidewalk to prevent trapping rainwater against the foundation. Close or adjust crawl space vents to prevent water intrusion.

Figure 11: Mold contamination in closet

3. Provide hangers to support DWV line in crawl space.
4. Replace the bathroom exhaust fan with a minimum 80 CFM fan, ducted to the exterior. Install a control on the fan that allows for delayed shut-off following bathroom use.
5. Return service to the bathroom sink and reconnect the sink drain.
6. Clean the interior mold with detergent and water. Replace drywall as required. Service heating system and ensure even and adequate heat distribution to all rooms.
7. Install a new range hood, vented to the exterior, over the gas range in the kitchen.
8. Ensure adequate insulation at the top plate of exterior walls to prevent mold at the wall/ceiling juncture.
9. Install louvered closet doors and maintain an air space on exterior walls inside the bedroom closets.

Inspection Number: 1-4
Address: 27 N. Ridge
Model Type: Ranch
Foundation: Basement
Construction: Block (CMU)
Heat Type: Natural Gas
Bedrooms: 4
Occupancy: 9
Age: 43 years

Figure 1 – 27 N. Ridge.

Mold and Moisture Conditions: Water damage and mold contamination was in both bathrooms. Significant site drainage and roof drainage issues around the house had led to occasional water intrusion in the basement.

Site Drainage and Rainwater Management: The site sloped dramatically from back to front. Erosion from rainwater drainage had carved deep ruts in the yard and undermined the concrete stairs and landings (Figure 2). The walk at the front of the house dammed rainwater against the foundation. Water flowing against the foundation had caused water damage to the concrete block structure (Figure 3) and provided opportunities for water leakage into the basement.

Figure 2: Soil erosion by foundation at the stairs

The roof drainage system was in need of significant maintenance and replacement of missing components, such as downspouts, leaders, and splashblocks. Rainwater concentrated by the downspouts at the base of the foundation can result in water entry into the basement (Figure 4). In the case of the front walk, the roof drainage system concentrated rainwater in a location that pooled against the foundation.

Figure 3: Water-damaged block foundation

Figure 4: Missing leader and foundation erosion

Basement Conditions: The floor and walls showed signs of water leakage from the exterior during periods of heavy precipitation (Figure 5). This observation was confirmed by observations related by the occupant.

Figure 5: Water damage at base of basement wall.

Mold was worst in the basement bathroom shower stall (Figure 6). The shower surround was painted concrete blocks, a difficult surface to clean. No exhaust fan was in this bathroom. Overcrowding and heavy usage of the shower without exhaust ventilation made mold prevention difficult. The window in the basement bathroom was deteriorated and moldy, indicating rainwater leakage at the window well.

Bathroom: The bathroom on the first floor had mold growth at the base of the tub surround (Figure 7). The tub surround was delaminating from the substrate, leaking, and in need of replacement. There was no exhaust fan in the bathroom. Splash from the shower had caused buckling in the floorboards at the entry door to the bathroom. There was minor moisture staining on the bathroom ceiling.

Figure 6: Mold in basement shower stall.

Mechanical: Grilles on the forced air supply ducts were clogged with dust and debris (Figure 8). This likely inhibited even heating throughout the home.

Figure 7: Mold on tub surround in first floor bathroom

Figure 8: Supply vent clogged with dust and debris

Occupant Notes: Nine people living in the overcrowded home. Some were smokers. Occupants reported no respiratory problems.

Recommendations:

1. Grade the yard and create swales to divert groundwater away from the foundation while it drains, following the natural slope from the rear of the house toward the front. Grade the soil away from the foundation. Make alterations to the sidewalk to prevent trapping rainwater against the foundation.

2. Repair damaged gutters and replace missing downspouts, leaders, and splash blocks.

3. Install exhaust fans in upstairs and downstairs bathrooms. Install a "through-the-wall" exhaust fan in the basement bathroom. Exhaust fans should have a minimum 80 CFM capacity and be ducted to the exterior. Install controls on the fans that allow for delayed shut-off following bathroom use.

4. After cleaning the mold off of the basement shower stall, install a cleanable, hard-surfaced shower surround to the walls. Replace tub surround in the first floor bathroom. Regularly clean bathroom surfaces.

5. Maintain supply and return grilles in a clean condition.

Inspection Number: 2-1
Address: 475 Wounded Knee Housing
Model Type: Split-level 2x4 Wood Frame
Foundation: Basement
Construction: Block (CMU)
Heat Type: Natural Gas
Bedrooms: 4
Occupancy: 9
Age: 28-30

Figure 1: 475 Wounded Knee Housing

Mold and Moisture Conditions: The residence was cluttered and dirty, making a full inspection of the conditions difficult. Mold was in the bathroom at the base of the tub surround and around the toilet base. Past plumbing leaks had caused problems in the base cabinet in the kitchen. Signs of modest moisture problems were noted in the basement.

Site Drainage and Rainwater Management: The site was fairly flat, though it appeared to drain fairly well to the front of the house. Common gutter problems were present, including missing leaders and/or splashblocks (Figure 2). There was evidence of severe soil erosion around the site.

Figure 2: Missing leader on downspout.

Basement/Crawl Space: Considerable clutter made the inspection of the basement difficult (Figure 3). The basement was subdivided into bedrooms that were not accessible for inspection. The drain for the washing machine was improperly installed, routed to the clean-out access for the main sewer line, thus containing no trap for the prevention of sewer gas (Figure 4). There were water stains and potential mold on the walls in the location of the washing machine.

Figure 3 – Basement clutter

Figure 4: Improper drain on washer, moisture damage on basement wall

Bathroom: Modest mold contamination was present around the tub surround and at the base of the toilet (Figure 5). Simple maintenance cleaning would address this condition. The bathroom had a noisy, inefficient exhaust fan.

Figure 5: Bathroom mold

Kitchen: Past plumbing leaks led to drywall deterioration and mold contamination under the sink (Figure 6). There were no signs of current leaks. No other moisture problems were detected in the main living space.

Occupant Notes: Nine people lived in the overcrowded home. The interviewee reported that his brother, a resident, had asthma. No other health problems were reported. (Note: a household member was not available for interview. The interviewee was an extended family member of the household)

Figure 6: Deterioration under kitchen sink.

Recommendations:

1. Repair damaged gutters and replace missing downspouts, leaders, and splash blocks.
2. Install an exhaust fan in the bathroom, with a minimum 80 CFM capacity and ducted to the exterior. Install controls on the fans that allow for delayed shut-off following bathroom use. Clean up existing mold in the bathroom with detergent and water.
3. Remove clutter from the basement. Provide a proper drain for the washing machine.
4. Clean the mold and deteriorated drywall from below the kitchen sink.

Inspection Number: 2-2
Address: 116 Wounded Knee Housing
Model Type: Raised ranch
Foundation: Basement
Construction: Block (CMU)
Heat Type: Natural Gas
Bedrooms: 4
Occupancy: 6
Age: 28-30 years

Figure 1 – 116 Wounded Knee Housing

Mold and Moisture Conditions: Minor surface mold was on the tub/shower surround and ceiling of the main bathroom. Some moisture damage was present in the basement bathroom. Winter humidifier use on the landing of the stairs had resulted in mold contamination in that area, and likely contributed to moisture problems in other areas of the home.

Site Drainage and Rainwater Management: Site drainage was generally good, with some grade away from the foundation. There were some localized depressions beside the foundation. The gutter system was missing downspouts and leaders at several locations (Figure 2). A brick border for foundation plantings served to trap rainwater against the foundation, threatening bulk water leakage into the window wells (Figure 3). This situation is critical in cases where downspouts and leaders are missing, thus concentrating rainwater in these locations.

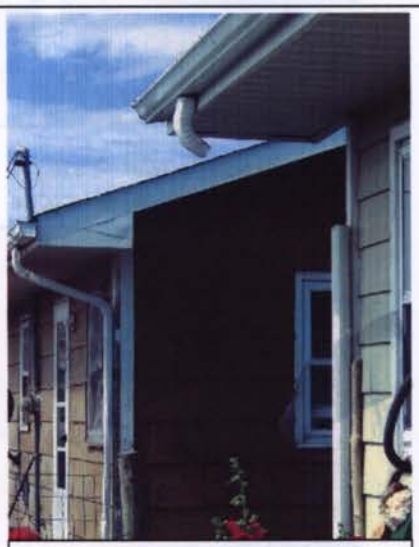

Figure 2: Missing gutter connection to downspout.

Basement: Much of the basement had been recently been drywalled, painted, and appeared in good condition. Residents indicated that water entry had been a problem. One corner of the basement appeared wet and moldy (Figure 4).

Figure 3: Brick border serving as a dam around foundation.

Figure 4: Mold in basement corner.

The bathroom in the basement had moisture damage above the shower (Figure 5). The bathroom exhaust vent was functioning poorly. The fixtures in the bathroom and laundry room sinks were both leaking profusely.

The landing on the stairs leading to the basement had dormant mold at the base of the wall (Figure 6). According to the residents, the landing was the location for the placement of a humidifier in the winter. Elevated local humidity from this equipment caused this problem.

First Floor Bathroom: The tub surround was stained and moldy at the base (Figure 7). There was mold contamination on the ceiling above the shower (Figure 8). The exhaust fan in the bathroom was weak.

Figure 5: Water damage above basement shower.

Figure 6: Mold on stair landing

Figure 7: Stained and moldy tub surround

Kitchen: Most of the kitchen surfaces were free of moisture problems, except on the wall and ceiling above the gas stove (Figure 9). Both cooking and the gas combustion generate significant moisture. The range hood at this house exhibited weak flow

Figure 8: Moldy ceiling

Figure 9: Condensation above stove.

performance, resulting in condensation-based moisture problems above the cooking surface.

Main Floor: One bedroom had moisture damage and mold growth at an exterior wall/ceiling juncture (Figure 10). Thermal bridging at this location is a common problem.

Mechanical: The hot water heater showed signs of flame roll out. The dryer vent was disconnected to its exterior outlet and thus venting into the basement.

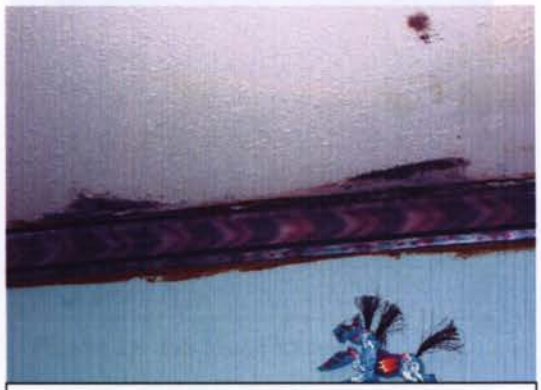

Figure 10: Condensation moisture and mold at the wall/ceiling juncture.

Occupant Notes: Six people lived in the house. One child developed asthma after moving into the house. The interviewee also reported mild, year-round respiratory problems developed after moving into the unit. The electric oven had been used for space heating 3 times during the winter months.

Recommendations:

1. Repair damaged gutters and replace missing downspouts, leaders, and splash blocks.
2. Make alterations to the brick border to prevent trapping rainwater against the foundation.
3. Install exhaust fans in upstairs and downstairs bathrooms. Install a through-the-wall exhaust fan in the basement bathroom with a minimum 80 CFM capacity and ducted to the exterior. Install controls on the fans that allow for delayed shut-off following bathroom use.
4. Replace tub surround on main floor bathroom.
5. Repair all plumbing leaks in the basement fixtures.
6. Reconnect dryer vent in the basement to prevent additional moisture loading.
7. Have the hot water heater professionally serviced and tuned.
8. Install a new range hood, vented to the exterior, over the gas range in the kitchen.
9. Ensure adequate insulation at the top plate of exterior walls to prevent mold at the wall/ceiling juncture.
10. Discontinue or limit winter use of the humidifier.

Inspection Number: 2-3
Address: 408 Mandersen
Model Type: Split-level 2x4 Wood Frame
Foundation: Basement
Construction: Block (CMU)
Heat Type: Natural Gas
Bedrooms: 4
Occupancy: 12
Age: 28-30 years

Figure 1 – 408 Mandersen.

Mold and Moisture Conditions: Significant mold growth was on the basement walls. Minor mold problems were in the bathroom and at the wall/ceiling junctures of one bedroom. The house had serious site drainage and rainwater management issues.

Figure 2: Site context

Site Drainage and Rainwater Management: The house was positioned in the middle of a block that was built on a hill, so that each site drained to the one below (Figure 2). There was good site drainage at the front and downhill sides of the site. At the uphill side of the house, however, the drainage pattern has lead to serious erosion problems (Figure 3).

Figure 3: Erosion on uphill side of house

The house was missing all downspouts. This had resulted in rainwater concentrating around the foundation (Figure 4). A concrete sidewalk magnified this problem by trapping water next to the foundation (Figure 5).

Figure 4: Rainwater concentration

Figure 5: Water trapped next to foundation by sidewalk.

Basement: The basement was finished with drywall halfway down the walls and was subdivided into sleeping spaces. This fact, along with excessive clutter, made the space difficult to inspect. There was clear evidence of mold growth on the lower, exposed block walls (Figure 6). Residents claimed that the basement leaked everywhere.

Figure 6: Mold on basement walls.

Bathroom: The bathroom had been recently painted. There was moisture damage in the bathroom next to the shower and behind the toilet (Figure 7). The exhaust fan was not operable.

Kitchen: Moisture damage was evident around the sink due to an insufficient backsplash. The gas stove did not have a functioning range hood.

Main floor: Minor condensation-based moisture problems were identified at the wall/ceiling juncture in one bedroom. Excessive clutter in the bedrooms made inspection difficult.

Mechanical: Occupants reported that humidifiers were used in two of the four bedrooms. It was also reported that the heating plant was inadequate.

Occupant Notes: Twelve people lived in the overcrowded home. At least one occupant smoked. One child was diagnosed with asthma and all four children located in basement bedrooms had assorted respiratory problems.

Figure 7: Bathroom moisture damage

Recommendations:

1. Repair damaged gutters and replace missing downspouts, leaders, and splash blocks.

2. Make alterations to the sidewalk to prevent trapping rainwater against the foundation.

3. Grade site to intercept rainwater drainage from uphill side and direct it away from the foundation and toward the street.

4. Install a new range hood, vented to the exterior, over the gas range in the kitchen.

5. Ensure adequate insulation at the top plate of exterior walls to prevent mold at the wall/ceiling juncture.

6. Limit or discontinue humidifier use in bedrooms to prevent moisture loading.
7. Remove clutter in basement and bedrooms.
8. Install an exhaust fan in the bathroom with a minimum 80 CFM capacity and ducted to the exterior. Install controls on the fans that allow for delayed shut-off following bathroom use.
9. Have the furnace professionally inspected and tuned.

Inspection Number: 2-4
Address: 435 Mandersen
Model Type: Raised Ranch
Foundation: Concrete Block Basement
Construction: Wood frame
Heat Type: Natural Gas
Bedrooms: 3
Occupancy: 14
Age: 28-30 years

Figure 1 – 435 Mandersen.

Mold and Moisture Conditions: Mold was along the basements walls. Overcrowding and the resultant excessive clutter made close inspection of this residence impossible.

Site Drainage and Rainwater Management: The site was raised well above the street, though the grade was flat around the foundation. All the downspouts were missing leaders, resulting in concentrated rainwater next to the foundation (Figure 2). A concrete sidewalk magnified this problem by trapping water next to the foundation (Figure 3).

Figure 2: Missing leader and foundation wetness

Figure 3: Surrounding walkway and missing leader.

Basement: The basement had been subdivided into numerous bedrooms. There was considerable clutter preventing complete inspection. There were signs of moisture entry into the basement. Signs of mold were visible as well (Figure 4).

Figure 4:Mold on basement bedroom walls and signs of moisture.

Occupant Notes: Fourteen people lived in the severely overcrowdedhome, including several being smokers. Personal possessions for fourteen people in a small house made inspection of the main living space impossible (Figure 5). Occupants reported that seven of the residents were diagnosed with asthma and were currently taking medication to treat it.

Figure 5: Excessive clutter in bedroom.

Recommendations:

1. Repair damaged gutters and replace missing downspouts, leaders, and splash blocks.

2. Make alterations to the sidewalk to prevent trapping rainwater against the foundation.

3. Ensuring a dry and mold resistant house can only be achieved by addressing the overcrowding and resultant clutter throughout the home.